

**PERSISTENCE OF INTER-APPLICATION COMMUNICATION PATTERNS AND
BEHAVIOR UNDER USER CONTROL**

5 Background of the Invention

1. Technical field

[0001] The present invention relates in general to a system and method for integrating applications based upon a user's actions. More particularly, the present invention relates to a system and method of integrating portlets so that source portlets are able to automatically provide data to target portlets.

2. Background art

[0002] The portal market is one of the fastest growing markets of computer software. A portal, in the context of a preferred embodiment of the present invention, may be defined as an application that provides a secure, single point of interaction with diverse information, business processes, and people, personalized to a user's needs and responsibilities. A portal, or "Web portal," is a Web site or service that offers a broad array of resources and services, such as e-mail, forums, search engines, and on-line shopping malls. Portals are typically accessed by a user on the Internet using a software application, such as a Web browser. A Web browser, or "browser," is a software application used to locate and display Web pages. Two popular browsers are NETSCAPE NAVIGATOR™ and MICROSOFT

INTERNET EXPLORER™. Both of these are graphical browsers, which means that they can display graphics as well as text. In addition, most modern browsers can present multimedia information, including sound and video, though they often require plug-ins in order to handle some formats.

[0003] The demand for portals drives rapid development of new technologies by different portal vendors in order to place their products in advantageous market positions. Not surprisingly, portals have evolved to their current state from a more primitive beginning. Originally, portals were mainly used as access points to different information sources with content being chosen by the portal operator. Next, portal customization provided users with the ability to choose the content that was displayed on the user's view of the portal using a Web browser. In this phase, the user was able to select information according to the user's interests and retrieve information related to his or her interests more expeditiously. Customized information delivery led to the introduction of business, or corporate, portals. Business portals were introduced to provide intra-business data within an organization.

[0004] The ongoing evolution of portals also left its footprint in the architecture of portal products. At first, portal-like products were delivered as pre-packaged applications that could be installed out of the box and included standard applications, which provided the portal functionality. As new applications were needed, vendors extended their products in order to satisfy requirements of

the new applications. Due to the use of proprietary designs, portal vendors added exclusive functionality to their portals, tying the success of a portal to the applications that the portal included. This led to the decomposition of monolithic portal structures and the creation of portal *frameworks*.

[0005] Portal products offered today employ architectures whereby the portal itself only implements standard functionality, such as security, authorization, authentication, aggregation, caching, user management, enrollment, rendering, and the like. The portal provides the infrastructure to integrate other application components. A typical embodiment of this type of architecture includes APIs for integrating applications so that applications from different vendors can be used so long as they match the portal product's API. According to current computing jargon, these applications are commonly called "portlets." Other synonyms for "portlets" in current use in the art include 'iViews' (a term utilized by SAP AG of Walldorf, Germany) or 'web parts' (a term utilized by Microsoft, Inc. of Redmond, WA).

[0006] Portlets are components that can be added to portals and are designed to run inside a portal's portlet container. Portlets may provide different functions ranging from simple rendering of static or dynamic content to application functions such as e-mail, electronic calendaring, and the like. Portlets are invoked indirectly

via the portal infrastructure and produce content that is suited for aggregation in larger pages.

[0007] While portlets allow separation of application components from each other and from the underlying portal, a challenge of using portlets is the difficulty in transmitting data that appears on one portlet to another portlet. For example, if one portlet displays orders for an organization and another portlet displays details for orders, vendors would have to "couple" the portlets to allow the user to send data from one portlet to another. In a business system, many portlets may be driven from the same pieces of information, such as order numbers, account numbers, and customer numbers. Closely coupling portlets to one another increases development requirements and maintenance of each portlet. In addition, coupling portlets may require activation of each of the coupled portlets even though the user only wants to view a subset of the coupled portlets.

[0008] In commonly assigned and copending application **US 10/448,968** (CHOUDHARY, ET AL.) 30.05.2003 , entitled "System and Method for User Driven Interactive Application Integration," a manner of using information from a first portlet in performing an action in a second portlet, referred to as "Click-to-Action" is disclosed. When a user selects one of the "Click-to-Action" icons or controls displayed in a Source portlet, he or she sees a menu of actions invocable with respect to target portlets on the

page that can process the properties (i.e., data items) that the icon or control is associated with. The user selects one of the actions from the menu, which results in a request being delivered to a Target portlet to perform the given action. The "Click-to-Action" feature described in the CHOWDHURY, ET AL. patent application, however, does not provide a way to persistently couple portlets.

[0009] In another commonly-assigned copending patent application, **US 10/292,074** (DUNNE, ET AL.) 12.11.2002 , a tool for allowing a user or administrator to couple portlets through a web-based interface was described. The DUNNE, ET AL. application describes the creation of "wires." A wire, as the term is used in the DUNNE, ET AL. application and herein, is a persistent association between a property in a source portlet and an action in a target portlet. When an event occurs that affects the property of a wire, the action associated with that property is triggered.

[0010] Although DUNNE, ET AL. tool significantly enhanced a user's ability to custom-configure a portal interface, one drawback to the tool was that a user would have to first interact with the portlets on the portal page itself, or in complex cases read additional documentation, then navigate to a separate tool interface display in order to couple or de-couple portlets. In a moderately complex portal, a user might have to switch back and forth between the portal and the tool interface a number of times in order to complete the user's configuration of the portal, which can be inconvenient.

[0011] What is needed, therefore, is a system and method for allowing a user to couple portlets without having to switch back and forth between a tool interface display and the portal itself.

Summary of the Invention

[0012] The present invention provides a method, computer
program product, and apparatus for allowing an end-user or
5 administrator to couple portlets in a portal so that
information may be shared between the portlets. In
particular, a preferred embodiment of the present invention
provides a simplified interface through which portlets may
be coupled through user interface events taking place on
10 the portal display itself. A database stores information
about the data items (called "properties") produced and
consumed by the portlets.

[0013] When the portal is displayed, if the user actuates a
control corresponding to a property in a registered
15 portlet, a menu of actions that can be performed with that
data by other portlets is provided to the user. In
addition to this "conventional" manner of actuating the
component, an alternative manner of actuating the component
is provided to the user such that if the user actuates the
20 control in this alternative manner, the user is provided
the option of making the chosen action "persistent," so
that the next time the control is actuated by the user, or
the associated property is otherwise produced, the chosen
action is performed automatically, without requiring the
25 user to choose an action.

Brief Description of Drawings

[0014] The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as a preferred mode of use, further objectives and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

[0015] **Figure 1** is a diagram of a web browser displaying a portal page in accordance with a preferred embodiment of the present invention;

[0016] **Figure 2** is a diagram depicting an overall view of the operation of a portal infrastructure in which a preferred embodiment of the present invention may be implemented;

[0017] **Figure 3** is a diagram depicting the operation of a "Click-to-Action" operation from the perspective of an end-user in accordance with a preferred embodiment of the present invention;

[0018] **Figure 4** is a diagram depicting a dialog box for prompting the user to specify whether to make a particular portlet action persistent in accordance with a preferred embodiment of the present invention;

[0019] **Figure 5** is a diagram depicting the result of associating a portlet action with a property in accordance with a preferred embodiment of the present invention;

[0020] **Figure 6** is a diagram depicting a dialog box for prompting the user to specify whether to eliminate an association between a property and a portlet action in

accordance with a preferred embodiment of the present invention;

[0021] **Figure 7** is a diagram depicting a tool-based interface for making changes to the wiring of portlets in accordance with a preferred embodiment of the present invention;

[0022] **Figure 8** is a sequence diagram depicting a process of displaying a portal page in accordance with a preferred embodiment of the present invention;

[0023] **Figure 9** is a sequence diagram depicting a process of wiring portlets in accordance with a preferred embodiment of the present invention;

[0024] **Figure 10** is a sequence diagram depicting a process of executing actions specified by portlet wiring in accordance with a preferred embodiment of the present invention;

[0025] **Figure 11** is a diagram providing a legend for interpreting Entity-Relationship diagrams such as **Figure 12**;

[0026] **Figure 12** is an Entity-Relationship diagram providing an exemplary schema for the database utilized in a preferred embodiment of the present invention; and

[0027] **Figure 13** is a block diagram of a computing device capable of executing software processes in accordance with a preferred embodiment of the present invention.

Detailed Description of Preferred Embodiment(s)

[0028] Turning now to **Figure 1**, an exemplary web browser **100** is provided in accordance with a preferred embodiment of the present invention. Web browser **100** is shown displaying a portal page. Included within this portal page are a number of portlets, map portlet **102**, weather information portlet **104**, and tourist information portlet **106**. Each of map portlet **102**, weather information portlet **104**, and tourist information portlet **106** is a separate web-based application executing on the web application server hosting the portal, and each portlet provides different, but related information. For example, weather information portlet **104** provides a text entry field **108** for entering the name of the city. When the user clicks submit button **110**, the current contents of portlet **104**'s portion of the display is replaced with information about the current weather conditions in the city specified in text entry field **108**. Likewise, when the user clicks submit button **114** in tourist information portlet **106**, the current contents of portlet **106**'s portion of the display is replaced with tourism-related information regarding the city entered in text entry field **112**.

[0029] **Figure 2** is a diagram depicting an overall view of the operation of a portal infrastructure in which a preferred embodiment of the present invention may be implemented. Actor **200** is the user of a web browser **202** executing on client computer **204**. Browser **202** issues requests through network **206** to web server **208**. A web application server **210**

resides on web server **208** and serves requested pages to browser **202**. A web application server can execute applications that access back-end systems and generate web content. Web application servers can either integrate web serving capability, as in the example provided in **Figure 2**, or be used in a configuration where the traditional web serving is offloaded to a web server, where the web application server is only forwarded some of the requests, based on the incoming Uniform Resource Locator (URL). One example of a web application server product that may operate in the context of a preferred embodiment of the present invention, either in conjunction with a web server or as an integrated web application server, is WEBSPHERE APPLICATION SERVER, which is a product of International Business Machines Corporation of Armonk, NY.

[0030] Web application server **210** is shown serving a portal page (portal interface **212**) generated via portal server **218**. Portal server **218**, is a specialized application to which requests for a portal (indicated, in a preferred embodiment, by URLs having a certain prefix) are handed over for processing. Since, from the perspective of web application **210**, portal server **218** is an application like any other web application, web application server **210** may invoke portal server **218** through any of a number of standard web application interfaces, such as the widely-used JAVA® servlets interface standard, for example. Portal server **218** processes portlets (such as portlets **214** and **216**), aggregates their markup, adds additional header/footer/formatting markup, and returns a resulting portal page **212** to web application server **210**. In a

preferred embodiment, portal server **218** is implemented as WEBSPHERE PORTAL SERVER, which is also a product of International Business Machines Corporation of Armonk, NY, and which is executed on a WEBSPHERE APPLICATION SERVER platform. One of ordinary skill in the art will recognize, however, that various portal servers are available from a number of vendors, and that the present invention is not limited to the use of any particular portal server, web server, or web application server.

[0031] Portlets **214** and **216** are two portlets that make up a portal served by web application server **210**. In a preferred embodiment portlets **214** and **216** are implemented in the form of specialized servlets. However, Hypertext Markup Language (HTML) or eXtensible HTML (XHTML) pages with embedded server-side scripting code and/or server-side includes (SSIs) may also be used in alternative embodiments of the present invention.

[0032] A preferred embodiment of the present invention makes use of what is known as the "servlet" paradigm of web application development, where "servlets" house the program control logic. A servlet is a piece of code that follows certain standard APIs (application programming interfaces) that allow it to be invoked by a web application server. Usually, the term "servlet" is used in conjunction with the JAVA® programming language of Sun Microsystems, Inc., although those skilled in the art will recognize that the term may be applied in the context of other programming languages and run-time environments, as well, and it is in this more general sense that the term "servlet" is used in

this document. In a typical JAVA® based implementation of a web application, however, servlets are used to house the program control logic of the application, JAVA® Server Pages (JSPs) are used to create the view (i.e., what is displayed to the user), and JavaBeans are created and passed to the JSPs by the servlets in order to allow the JSP-generated view to reflect the computational results and/or the computational state of the servlets.

[0033] Servlets, JSPs, and JavaBeans allow the design of a web application to be decomposed cleanly according to a model-view-controller (MVC) pattern. MVC is a manner of partitioning the design of interactive software into conceptual levels of abstraction that fall into the three categories of "model," "view," and "controller". In general, the "model" represents the internal data of the program and the relationships between the data, the "view" represents how a user views the state of the model, and the "controller" is represents the manner in which the user changes the state or provides input. The data and code encapsulation provided by servlets, JSPs, and JavaBeans simplifies the design of web applications by allowing the applications to conform to an MVC design pattern.

[0034] "Server-side scripting code" is program code that is directly embedded into the content of an HTML/XHTML document through the use of special markup tags. When a web page with server-side scripting code is served by a web server, the web server identifies the presence of server-side scripting code and causes the code to be executed before the web page is transmitted to the client.

Typically, server-side scripting code is used to place dynamic content into a web page before the page is transmitted to a web client. A number of server-side scripting languages and programming tools are available in the art. Java Server Pages (JSP), for example, is a technology (available from Sun Microsystems, Inc.) that allows Java program code to be embedded in an HTML document for server-side execution. Other server-side programming systems include Active Server Pages (a product of Microsoft, Inc.) and PHP, which is a popular open-source programming language and interpreter for producing server-side scripting code. "Server-side include" (SSI) is a similar mechanism for placing dynamic text in web documents in which the web server replaces special tags in a source HTML/XHTML document with other text and/or markup (such as a time/date stamp or the contents of another HTML file, for example). The popular Apache open-source web server provides SSI capabilities. Server-side scripting and server-side includes were designed as a simplification over previous forms of providing dynamic web content, such as CGI (Common Gateway Interface) scripting, which are less commonly used today as a result. One of ordinary skill in the art will recognize that although a preferred embodiment of the present invention utilizes servlets, one may also practice the teachings of the present invention using other forms of dynamic content production, including server-side scripting and CGI, without departing from the scope and spirit of the present invention.

[0035] Portal server **218**, in a preferred embodiment, combines the data and program content of portlets **214** and **216** by simply consolidating the raw source HTML/XHTML (including any server-side scripting code or SSIs) into a single HTML/XHTML document with some additional "glue/wrapper" HTML/XHTML markup to specify the arrangement of portlets on portal page **212**. The additional markup may itself be quite significant to the operation of the portal, and can include (in addition to markup for arranging portlet views and in a non-limiting sense), headers, footers, portal navigation links, links to common services, search bars, client-side executable code (such as JavaScript, *q.v.*), and the like.

[0036] Portal page **212** is served to browser **202** (via web/application server **210** in this preferred embodiment) as if it were a monolithic page. Since server-side scripting code for both portlets **214** and **216** is included in portal page **212**, web application server **210** may execute whatever server-side scripting code is present in portal page **212** as if the page were originally written as a single HTML/XHTML page with server-side scripts. Web application server **210** then serves the resulting page (with server-side scripts processed) to browser **202**. Alternatively, the server-side scripting code may be executed prior to assembly of portal page **212** from its constituent portlets. For example, in a preferred embodiment utilizing WEBSPPHERE PORTAL SERVER, portal server **218** runs as an application within web application server **210** and utilizes the JSP processor of web application server **210** to execute the JSP scriptlets for portlets **214** and **216** individually prior to the assembly of portal page **212**, so that no post-processing of the

assembled portal page **212** by web application server **210** is necessary.

[0037] One of ordinary skill in the art will recognize that an alternative method of serving dynamic portal content would be to execute each of portlets **214** and **216** as a separate process (for example, as separate CGI scripts) to obtain HTML/XHTML output and then consolidate the output of the two portlets into a single HTML/XHTML page for serving to browser **202**. One of ordinary skill in the art will also recognize the content served to browser **202** need not be HTML/XHTML content, but may comprise any of a number of content types presently in existence or developed in the future. For example, the content produced by portal **214** may be in a format based on the eXtensible Markup Language (XML), such as eXtensible Stylesheet Language-Formatting Objects (XSL-FO), Scalable Vector Graphics (SVG), or Wireless Markup Language (WML). In addition the content types produced by the different portlets need not be homogeneous. For example, portlet **214** may produce an SVG graphic while portlet **216** produces a document in PDF (Portable Document Format). PDF is a published document format produced by Adobe, Inc.

[0038] The present invention is directed to a method, computer program product, and data processing system for allowing a user to couple or "wire" a pair of portlets to allow information to be shared between portlets on a portal page in the context of using the portlets. **Figure 3** is a diagram of a web browser displaying a portal having portlet wiring capabilities in accordance with a preferred

embodiment of the present invention. In this preferred embodiment, the user interface controls provided by the portlets can be actuated in two alternative manners, a "conventional manner" and an "alternative manner." When a

5 portlet control is actuated in the "conventional" manner, the portlet exhibits its normal behavior. For example, the normal behavior of map portlet **102** would be to display a menu (such as menu **300** in **Figure 3**), and allow the user to select an action (or actions) to be taken in response to that menu selection (e.g., display city information on map portlet **102**, display weather information for the selected city on portlet **104**, etc.). The "Click-to-Action"

10 techniques described in **US 10/448,968** (CHOUDHARY, ET AL.) 30.05.2003 , hereby incorporated herein by reference, may be applied to achieve this behavior.

15 **[0039]** When a portlet control is actuated in the "alternative" manner, the user is given also provided with a menu of action choices, but prior to dispatching the selected action, an additional dialog is shown. This additional dialog asks the user whether or not to "persist" the selected action (i.e., by wiring the property corresponding to the actuated portlet control to an action to be performed by a target portlet). According to our terminology, a "property" is a data item that is produced

20 by, consumed by, stored by, or otherwise associated with a portlet. For instance, in the example provided in **Figure 3**, if the user holds down the "Control" (or "Ctrl") key

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while clicking on city **302** in map portlet **102** (as opposed to simply clicking city **302** with no keypress), a menu **300** is displayed to allow the information represented by city **302** (i.e., "Houston, TX") to be provided to the same or another portlet to perform an action. For example, menu **300** gives the user the option of sending the information to weather information portlet **104**, tourist information portlet **106**, map portlet **102**, or to all three portlets.

[0040] Once the user has made a selection of an action, the user is then prompted to specify whether to make that action "persistent." That is, the user is given the option of having that action be associated with the user interface control or property in the future. In **Figure 4**, for instance, a dialog box **400** is displayed in response to the user's selecting a particular action (for example, sending the city information from map portlet **102** to weather information portlet **104**). If the user clicks "Yes" button **402**, the selected action will be associated with the city information from map portlet **102** such that whenever a city on map portlet **102** is clicked, the identity of that city is submitted to one or more of portlets **102**, **104**, and **106**. For the purpose of example, we will assume that the user selected that the information be submitted to weather information portlet **104** so that whenever a city is clicked (such as city **302**), that city's current weather report **500** is displayed by weather information portlet **104**, as depicted in **Figure 5**. According to our terminology, weather information portlet **104** is said to be "wired" to

map portlet **102**; by associating the city information from map portlet **102** with the city submission and weather reporting action of weather information portlet **104**, the user is said to have created a "wire" coupling the two portlets.

[0041] Returning now to **Figure 4**, the display of dialog box **400** may be triggered by the use of *client-side* scripting code embedded in the HTML/XHTML code for the portal. Unlike *server-side* scripting code (such as JSP or PHP code), *client-side* scripting code is transmitted in raw, unprocessed form to the user's browser. The browser then executes the embedded code. JavaScript is a popular client-side scripting language that is supported by most modern web browsers in current use. JavaScript and other client-side scripting languages generally allow certain procedures, function, or other client-side scripting code to be associated with user-interface events in the browser such that when a particular user interface event (such as a mouse click) occurs, particular lines of client-side scripting code are executed. Thus, one method of triggering dialog box **400** is to embed client-side scripting code (e.g., JavaScript code) into the portal page that is triggered by the user interface event of "Control-clicking" on particular controls in the portal page. The client-side scripting code displays the dialog box and communicates the user's response back the web application server to direct further processing. In a preferred embodiment of the present invention, the client-side scripting code is added

to the portal page by the portal server in the process of assembling the component portlets into a single portal page.

[0042] Other options are provided by dialog box **400** in **Figure**

5 **4**. The user has the option of deciding to perform the associated action for a single time only, in which case, the user may click "No" button **404** to opt out of creating a

wire and to exit dialog box **400**. If the user has administrative privileges with respect to the web
10 application server hosting the portal, an additional "Yes, all users" button **406** may also be provided in order to

allow that administrative user to create a wire that holds for all users of a portal. One of ordinary skill in the art will recognize that it is not unusual for websites to

15 require their end-users to log in with a user name and/or password in order to access certain services or in order to provide certain user-customized features. A preferred embodiment of the present invention expands upon this

general concept by allowing a user to customize the manner in which portlets collaborate when that particular user
20 accesses a portal. The additional feature of allowing an administrative user to create wires that apply to all users

allows such an administrative user to enjoy the same flexibility in producing a base portal site design.

25 **[0043]** In a preferred embodiment of the present invention, the reverse operation, namely deleting a wire, may be executed in a similar fashion, as shown in **Figure 6**. In this example, the user has clicked a city **600** in map portlet **102** while holding down the Control key (i.e., the

user has employed the alternative manner of actuating the map portlet **102**'s imagemap control). This Control-click operation causes a dialog box **602** to be displayed to allow the user to delete the wire associated with map portlet **102** that was created in **Figure 4**.

[0044] The "on-the-portal" user interface for creating and deleting wires, depicted in **Figures 3-6** may also be supplemented with a tool-based interface for creating and deleting wires, such as that described in **US 10/292,074** (DUNNE ET AL.) 12.11.2003 . Such an interface, tool-based interface **702**, is shown in **Figure 7**. An advantage of providing the option of using tool-based interface **702** is that a user has the ability to see a list **704** of all of the wires that have been created. This allows the user to understand the operation of the entire portal at a glance. Delete icons, such as delete icon **706**, are provided to allow a user to delete wires from list **704**. A submissable form made up of drop-down lists **708**, **710**, **712**, and **714** allow a new wire to be specified by mapping a property (list **710**) from a source portlet (list **708**) to a receiving action (list **714**) of a target portlet (list **712**). Checkbox **716** allows an administrative user to specify whether the wire should exist for all users (i.e., that the wire should be a "global wire"). Clicking "New Wire" button **718** causes the web form to be submitted and the new wire to be created.

[0045] **Figure 8** is a sequence diagram in UML (Uniform Modelling Language) describing a process of displaying a portal page in accordance with a preferred embodiment of

the present invention. Across the top of the sequence diagram are objects **801**, **803**, **805**, **807**, and **810**, which represent the major components of a software system implementing a preferred embodiment of the present invention. It should be noted that although UML is associated with the modelling of object-oriented systems and uses object-oriented terminology, the use of UML in **Figures 8-10** of the present application is not intended to imply that the present invention must be implemented in an object-oriented programming language or according to an object-oriented paradigm.

[0046] The depicted process begins with browser **801** requesting the portal page from web application server **803** (message **802**). Web application server **803** then determines from the URL of the request that a portal page is requested (message **804**). This causes web application server **803** to pass the request on to portal server **805** (message **806**). Portal server **805** then queries a database **807** to determine a list of portlets present on the requested page (messages **808**, **810**). Database **807** (described in more detail in **Figure 12**) provides information about which portlets are present on which pages and also provides information about the properties and actions associated with each portlet. Since database queries are relatively expensive operations, in a computational sense, a preferred embodiment of the present invention, in order to enhance performance, caches the results of its database queries to allow those results to be utilized without necessarily requiring that the query be actually executed in the database each time. Portal server **805** then assembles the portlets into a portlet page,

adding additional markup for headers and layout and client-side scripting code as necessary (message **812**).

[0047] The process of invoking the portlets themselves then begins. If a particular action for a portlet is specified in the URL of the request, an identification of that action is then delivered to the portlet (e.g., portlet **809**) (messages **814**, **816**). Portal server **805** then requests the markup for each portlet in the page (messages **818**, **820**). To the obtained portlet markup, portal server adds additional markup for footers and other features that are located after the portlet markup itself in the portal page (message **822**). This portal page is then returned to web application server **803** (message **824**), which then serves the generated portal page as a monolithic page of markup (message **826**).

[0048] **Figure 9** is a sequence diagram depicting a process of wiring portlets in accordance with a preferred embodiment of the present invention. Browser **801** executes client-side scripting code (in this example, JavaScript code) in response to the user actuating a user interface control in a portal page using the "alternative manner" of actuation to generate a wire (message **900**). This client-side scripting code generates a menu of actions that can be selected by the user (as in **Figure 3**) (message **902**). In response to the user's selecting action(s) from the menu (message **904**), the client-side scripting code then provides a dialog box asking the user whether the user wishes to have the action automated in the future (i.e., whether the user wishes to create a wire for the action) (message **906**).

In response to the user's choosing "Yes" (message **908**), the client-side scripting code dispatches the action, along with an indication to automate the action, to web application server **803** (message **910**). Web application server **803** then forwards the dispatched action to portal server **805** (message **912**). This causes portal server **805** to record in database **807** wire(s) that connect the source property (associated with the clicked icon) with the chosen target action (messages **914**, **916**). Finally, portal server **805** dispatches the action to the appropriate portlet(s) (portlet **809**) for processing (message **918**), with the result returned, via portal server **805** and web application server **803**, to browser **801** for display to the user (messages **920**, **922**, and **924**).

[0049] **Figure 10** is a sequence diagram describing a process of triggering a wired action in a portlet in accordance with a preferred embodiment of the present invention. Browser **801** submits a request to web application server **803** to perform an action on a portlet (e.g., by actuating a user interface control on the portlet) (message **1012**). Web application server **803** forwards the request to portal server **805**, in response to a determination that the request is directed to a portlet (message **1014**). Portal server **805** then dispatches the action to a first portlet **809** for execution of the action (message **1016**). Portlet **809** then generates properties (i.e., items of data) in portal server **805** as a result of executing the action (messages **1018**, **1020**). Once portlet **809** has completed its dispatched action (message **1022**), portal server **805** queries database

807 to determine which wires (if any) are connected to the properties generated by portlet 809 (messages 1024, 1026). If any such wires exist, these properties are dispatched to the appropriate portlet(s) (represented by portlet 811) so as to perform the corresponding actions defined by the wires (messages 1028, 1030). It should be noted that this process of dispatching properties to trigger additional actions can occur repeatedly such that a transitive closure of associated actions is performed with respect to a given property (the transitive relation being the mapping of a given property to the set of properties generated by the actions triggered by the given property, as defined by the wires in database 807). Finally, the end result of performing all of the triggered actions is returned, via portal server 805 and web application server 803, to browser 801 for presentation to the user (messages 1032, 1034).

[0050] As can be observed from **Figures 8-10**, a preferred embodiment of the present invention relies on a database (e.g., database 804) for storing information regarding the properties produced and consumed by portlets. **Figure 11** provides a diagrammatic view (in the form of an entity-relationship diagram) of a possible schema for such a database. **Figure 11** is intended to be an example of the organization of such a database and also to provide a semantic description of wires, properties, and actions.

[0051] The E-R (entity-relationship) approach to database modelling provides a semantics for the conceptual design of databases. With the E-R approach, database information is represented in terms of entities, attributes of entities,

and relationships between entities, where the following definitions apply. The modelling semantics corresponding to each definition is illustrated in **Figure 11**. **Figure 11** is adapted from Elmasri and Navathe, *Fundamentals of Database Systems*, 3rd Ed., Addison Wesley (2000), pp. 41-66, which contains additional material regarding E-R diagrams and is hereby incorporated herein by reference.

[0052] **Entity:** An entity is a principal object about which information is collected. For example, in a database containing information about personnel of a company, an entity might be "Employee." In E-R modelling, an entity is represented with a box. An entity may be termed weak or strong, relating its dependence on another entity. A strong entity exhibits no dependence on another entity, i.e. its existence does not require the existence of another Entity. As shown in **Figure 11**, a strong entity is represented with a single unshaded box. A weak entity derives its existence from another entity. For example, an entity "Work Time Schedule" derives its existence from an entity "Employee" if a work time schedule can only exist if it is associated with an employee. As shown in **Figure 11**, a weak entity is represented by concentric boxes.

[0053] **Attribute:** An attribute is a label that gives a descriptive property to an entity (e.g., name, color, etc.). Two types of attributes exist. Key attributes distinguish among occurrences of an entity. For example, in the United States, a Social Security number is a key attribute that distinguishes between individuals.

Descriptor attributes merely describe an entity occurrence (e.g., gender, weight). As shown in **Figure 11**, in E-R modelling, an attribute is represented with an oval tied to the entity (box) to which it pertains.

5 **[0054]** In some cases, an attribute may have multiple values. For example, an entity representing a business may have a multi-valued attribute "locations." If the business has multiple locations, the attribute "locations" will have multiple values. A multi-valued attribute is represented by concentric ovals, as shown in **Figure 11**. In other cases, a composite attribute may be formed from multiple grouped attributes. A composite attribute is represented by a tree structure, as shown in **Figure 11**. A derived attribute is an attribute that need not be explicitly stored in a database, but may be calculated or otherwise derived from the other attributes of an entity. A derived attribute is represented by a dashed oval as shown in **Figure 11**.

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20 **[0055]** **Relationships:** A relationship is a connectivity exhibited between entity occurrences. Relationships may be one to one, one to many, and many to many, and participation in a relationship by an entity may be optional or mandatory. For example, in the database containing information about personnel of a company, a relation "married to" among employee entity occurrences is one to one (if it is stated that an employee has at most one spouse). Further, participation in the relation is optional as there may exist unmarried employees. As a

second example, if company policy dictates that every employee have exactly one manager, then the relationship "managed by" among employee entity occurrences is many to one (many employees may have the same manager), and mandatory (every employee must have a manager).

[0056] As shown in **Figure 11**, in E-R modelling a relationship is represented with a diamond if it relates one or more entities, and may also be represented with an n-sided polygon if it relates more than two entities. The cardinality ratio (one-to-one, one-to-many, etc.) in a relationship is denoted by the use of the characters "1" and "N" to show 1:1 or 1:N cardinality ratios, or through the use of explicit structural constraints, as shown in Figure 11. When all instances of an entity participate in the relationship, the entity box is connected to the relationship diamond by a double line; otherwise, a single line connects the entity with the relationship, as shown in **Figure 11**. In some cases, a relationship may actually identify or define one of the entities in the relationship. These identifying relationships are represented by concentric diamonds, also shown in **Figure 11**.

[0057] **Figure 12** is an Entity-Relationship diagram providing an exemplary schema for the database (e.g., database 804) utilized in a preferred embodiment of the present invention. It should be noted that E-R modelling of databases is well-known in the database design and implementation art and that one of ordinary skill in the art would be capable of producing a variety of specific

database implementations from the schema diagram provided in **Figure 12**, including relational database, object-oriented database, and object-relational database implementations, as well as others. Systematic procedures and algorithms are also available to allow direct translation of an E-R schema into a semantically equivalent database implementation.

[0058] We now turn to the semantic content of **Figure 12**. A portal (entity **1202**) is associated (relationship **1203**) with a number of pages (entity **1204**), each of which is made up of (relationship **1208**) portlets (entity **1212**). Each page, being accessible through a web browser, has a URL (uniform resource locator) as an attribute (attribute **1206**). A layout attribute **1210** is also associated with relationship **1208**, providing information about the manner in which the constituent portlets are to be arranged in a portal page. Relationship **1201** maps users (entity **1200**) with portals (entity **1202**), since different users may have access to different portals.

[0059] Turning now to portlet entity **1212**, a portlet produces (relationship **1214**) properties (entity **1216**) and performs (relationship **1218**) various actions (entity **1220**) that consume (relationship **1222**) properties (entity **1216**). A wire (entity **1224**) maps a single "producer" (entity **1228**) to a single "consumer" (entity **1234**) (relationships **1226** and **1232**). A "producer" (entity **1228**) is (relationship **1231**) a portlet (entity **1212**) that produces (relationship **1230**) a particular property (entity **1216**), while a "consumer" (entity **1234**) is (relationship **1236**) an action

(entity **1220**) that consumes (relationship **1222**) the property (entity **1216**) produced by the corresponding producer (entity **1228**), as associated by wire entity **1224** and relationships **1226** and **1232**. A producer and consumer may be able to share a property based on some criterion associated with the property, such as a data type. A user (entity **1200**) may make use of (relationship **1238**) a number of wires (entity **1224**).

[0060] **Figure 13** illustrates information handling system **1301** which is a simplified example of a computer system capable of performing the computing operations described herein. Computer system **1301** includes processor **1300** which is coupled to host bus **1302**. A level two (L2) cache memory **1304** is also coupled to host bus **1302**. Host-to-PCI bridge **1306** is coupled to main memory **1308**, includes cache memory and main memory control functions, and provides bus control to handle transfers among PCI bus **1310**, processor **1300**, L2 cache **1304**, main memory **1308**, and host bus **1302**. Main memory **1308** is coupled to Host-to-PCI bridge **1306** as well as host bus **1302**. Devices used solely by host processor(s) **1300**, such as LAN card **1330**, are coupled to PCI bus **1310**. Service Processor Interface and ISA Access Pass-through **1312** provides an interface between PCI bus **1310** and PCI bus **1314**. In this manner, PCI bus **1314** is insulated from PCI bus **1310**. Devices, such as flash memory **1318**, are coupled to PCI bus **1314**. In one implementation, flash memory **1318** includes BIOS code that incorporates the necessary processor executable code for a variety of low-level system functions and system boot functions.

[0061] PCI bus **1314** provides an interface for a variety of devices that are shared by host processor(s) **1300** and Service Processor **1316** including, for example, flash memory **1318**. PCI-to-ISA bridge **1335** provides bus control to handle transfers between PCI bus **1314** and ISA bus **1340**, universal serial bus (USB) functionality **1345**, power management functionality **1355**, and can include other functional elements not shown, such as a real-time clock (RTC), DMA control, interrupt support, and system management bus support. Nonvolatile RAM **1320** is attached to ISA Bus **1340**. Service Processor **1316** includes JTAG and I2C busses **1322** for communication with processor(s) **1300** during initialization steps. JTAG/I2C busses **1322** are also coupled to L2 cache **1304**, Host-to-PCI bridge **1306**, and main memory **1308** providing a communications path between the processor, the Service Processor, the L2 cache, the Host-to-PCI bridge, and the main memory. Service Processor **1316** also has access to system power resources for powering down information handling device **1301**.

[0062] Peripheral devices and input/output (I/O) devices can be attached to various interfaces (e.g., parallel interface **1362**, serial interface **1364**, keyboard interface **1368**, and mouse interface **1370** coupled to ISA bus **1340**.

Alternatively, many I/O devices can be accommodated by a super I/O controller (not shown) attached to ISA bus **1340**.

[0063] In order to attach computer system **1301** to another computer system to copy files over a network, LAN card **1330** is coupled to PCI bus **1310**. Similarly, to connect computer system **1301** to an ISP to connect to the Internet using a

telephone line connection, modem **1375** is connected to serial port **1364** and PCI-to-ISA Bridge **1335**.

[0064] While the computer system described in **Figure 13** is capable of executing the processes described herein, this computer system is simply one example of a computer system. Those skilled in the art will appreciate that many other computer system designs are capable of performing the processes described herein. It is important to note that while the present invention has been described in the context of a fully functioning data processing system, those of ordinary skill in the art will appreciate that the processes of the present invention are capable of being distributed in the form of a computer readable medium of instructions or other functional descriptive material and in a variety of other forms and that the present invention is equally applicable regardless of the particular type of signal bearing media actually used to carry out the distribution. Examples of computer readable media include recordable-type media, such as a floppy disk, a hard disk drive, a RAM, CD-ROMs, DVD-ROMs, and transmission-type media, such as digital and analog communications links, wired or wireless communications links using transmission forms, such as, for example, radio frequency and light wave transmissions. The computer readable media may take the form of coded formats that are decoded for actual use in a particular data processing system. Functional descriptive material is information that imparts functionality to a machine. Functional descriptive material includes, but is not limited to, computer programs, instructions, rules,

facts, definitions of computable functions, objects, and data structures.

[0065] While particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that, based upon the teachings herein, that changes and modifications may be made without departing from this invention and its broader aspects. Therefore, the appended claims are to encompass within their scope all such changes and modifications as are within the true spirit and scope of this invention. Furthermore, it is to be understood that the invention is solely defined by the appended claims. It will be understood by those with skill in the art that is a specific number of an introduced claim element is intended, such intent will be explicitly recited in the claim, and in the absence of such recitation no such limitation is present. For non-limiting example, as an aid to understanding, the following appended claims contain usage of the introductory phrases "at least one" and "one or more" to introduce claim elements. However, the use of such phrases should not be construed to imply that the introduction of a claim element by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim element to inventions containing only one such element, even when the same claim includes the introductory phrases "one or more" or "at least one" and

indefinite articles such as "a" or "an"; the same holds true for the use in the claims of definite articles.